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Information technology pathways in education: Interventions with middle school students

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ABSTRACT

Although there continue to be many efforts to increase STEM interest in the younger audience, shortages in the STEM fields continue to exist. In order to combat this shortage, this study sought to implement supplementary hands-on, problem-based learning into the classroom to positively influence teenagers' attitudes regarding STEM and IT through an industry outreach partnership. This study was seeking the implications on students' career readiness skills as well as gauging career interest towards STEM fields. The study also examined STEM and IT from the educator side to see if educators, with no technology endorsements, had the time and ability to correctly implement the activities. These two items have large implications for future supplementary STEM-IT implementations in the classroom from both the student and educator perspectives. In order to fully capture these two diverse viewpoints, 645 students and their educators were surveyed in a pre-posttest format. One of the most noteworthy findings was the students lack of knowledge regarding IT, including what the acronym meant, technical skills needed and career expectations. Educators also reported an increase in knowledge and appreciation of the real-world, hands-on curricular activities. Again, these results indicate significant finds which could have an impact on implementing supplementary STEM-IT curricula in the middle grades.

Science, technology, engineering, and math (STEM) educational outreach is designed to promote careers in the region's high-growth, high-demand information technology field. A primary purpose of STEM educational outreach is to provide students with relevant, rigorous educational experiences to raise career awareness among students within the information technology field (IT or the Technology in STEM). This type of outreach aims to engage students in projects that foster curiosity and interest, and promote their continued participation with IT into secondary education and beyond (NCE, 2011; NDYTI, 2017). The abilities to critically think and reason along with other soft skills like teamwork and communication are attributes needed in any professional career field, but are highly sought after in STEM professions (Lou, Shih, Diez, & Tseng, 2011; Mattern, Allen, & Camara, 2016). Alongside of soft skills, hands-on, problem-based learning labs provide students an opportunity to actively explore and potentially increase interest in STEM, IT-focused careers. Specific skills that develop from problem-based, hands-on STEM activities are critical and analytical thinking regarding real-world problems, cooperative learning and communication skills, and the promotion and sense of self-efficacy (Bass, Dahl, & Panahandeh, 2016; Torp & Sage, 2002). These abilities are important to students as they move towards adulthood and often serve as predictors of career and academic achievement. Moving forward into post-secondary education, students are more likely to choose STEM and IT majors based on their self-efficacy with science, technology, engineering and math skills (Hall & Ponton, 2005).

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Table 1
Short-term measures within the STEM outreach project.

Short-term measures
1 Expose more than 1000 middle school students to careers in IT each year to create measurable excitement for those career pathways.
2 Strengthen the perceptions of fundamental career readiness skills of the students (e.g. communication, critical thinking, problem solving, teamwork).
3 Give the IT industry an opportunity to help build useful digital technology for the middle schools.
4 Provide middle school educators experiences needed to mold curriculum to match the IT industry needs.

Implementing educational outreach activities that include hands-on, problem-based learning can positively influence teenagers' attitudes regarding STEM and IT. Thus, these activities are important to ensure STEM career longevity (Schrum & Levin, 2016; Tseng, Chang, Lou, & Chen, 2013).

To promote soft skills and hands-on, problem-based learning, this STEM educational outreach project was guided by seven goals, which included both short and long-term measures. This project was integrated into all existing middle school grade levels within a rural Midwest community. This project's primary focus was to provide middle school students with industry-driven, rigorous educational experiences to raise their IT career awareness; engage them in projects that foster curiosity and interest; and promote their continued participation in STEM, post-secondary and beyond. In this paper, the short-term measures from this STEM educational outreach project (Table 1) were examined concentrating on #1, #2 and #4 of the table, to determine whether this project made a difference in the perceptions of required soft skills; whether a difference in perceptions of future IT careers was created by time or by middle school grade; what perceived roadblocks would prevent a student from pursuing a career in IT; and if the project helped middle school educators enhance STEM curriculum, particularly, Technology focused curriculum.

1. Literature review

Based on previous research, the field of IT, which is a part of the "T" in STEM, is experiencing a decline in the number of skilled IT employees and employee productivity. This is further causing an overall decline in employment and economic growth (Rugarcia, Felder, Woods, & Stice, 2000; Windschitl, 2009). As the wide variety of industry services becomes more intertwined within IT, the demand for skilled employees continues to rise. In fact, the United States Department of Labor predicts IT as one of the top twenty growing fields in terms of the demand for employees in the next 10 years (US Dept of Labor, 2018). There is currently a limited base of research specifically targeted towards middle school students and their understanding of IT careers. This STEM educational outreach project was created for children in the middle school age range to address the lack of information technology (IT) career development and career readiness skills in the Midwest area. This project focused on teaching career readiness skills through hands-on, problem-based learning activities to spark student interest and knowledge in the IT career field. As such, this project and subsequent paper seeks to build on the limited research in this area.

1.1. Engaging students to pursue STEM, highlighting IT

Students who choose to pursue STEM usually make this decision during high school based on their interest in one of the STEM subject matters (Maltese & Tai, 2011). Holdren, Lander, and Varmus (2010) predict that students' interest in STEM must be awakened before eighth grade. After eighth grade and into high school, if a student's interest in STEM has not been awakened, students often report that STEM activities are too challenging and too hard, which act as large deterrents and barriers to entry for post-secondary STEM majors and then careers (Maltese & Tai, 2011; Mohr-Schroeder et al., 2014; Wang, 2013). However, if STEM interest can be developed in students, by eighth grade or earlier, students are three times more likely to pursue STEM college majors and/or careers (DeJarnette, 2012). In addition to this short time frame for engaging students' interest in STEM, underrepresented minority groups, based on ethnicity and gender, enter STEM fields at a much lower rate when compared to other groups (Carver et al., 2017). Therefore, the engagement of all students into STEM or Technology must occur earlier in the middle school grades or earlier to fully capture and redirect students' interest toward future STEM careers (Elam, Donham, & Soloman, 2012; Little & León de la Barra, 2009; Nugent, Barker, Grandgenett, & Adamchuk, 2010; Yelamarthi & Mawasha, 2008).

Increasing interest in science and engineering ("S" and "E" in STEM) has been accepted by some secondary schools and can be seen in curriculums like Project Lead The Way and The Infinity Project as well as after school programs (Mouza, Marzocchi, Pan, & Pollock, 2016; Project Lead the Way, 2017; The Infinity Project, 2017). However, curricula and educational outreach for Technology and advanced Technology-based curricula that specifically progresses learning in topics, such as computer programming, computer networking and systems, computer systems development and life cycle, is scarce to non-existent. Although Schrum et al. (2015) does present several case studies depicting successfully classroom technology integration, advanced Technology curricula remains sparse at the middle school. Perhaps, this is due to the very nature of most middle school curricula, which contain very few Technology course(s) that focus specifically on learning and creating with advanced technologies.

1.2. Career readiness skills in STEM, highlighting IT

Alongside of engaging students in STEM—particularly IT—there is large value in providing students with much needed career readiness skills intertwined with technical skills. Moreover, many of the esoteric technical skills can be taught on the job in a STEM career, while fundamental career readiness skills need to be present the first day on the job. Not only do students need to be college-ready for success in a STEM program, but students also need to be career ready (Hooley, Marriott, & Sampson, 2011; Mattern et al., 2016). Instead of focusing so intently on forcing technical skill development through rote learning, students must learn how to ask appropriate questions and prioritize tasks in order to be able to teach themselves how to solve a technical problem (Bass et al., 2016; Sahin, Ayar & Adiguzel, 2014). Critical thinking and problem solving skills in the IT field are necessary to meet the needs of this era. Alongside of communication and problem solving, researchers have listed critical thinking and collaboration with leadership to be among the top career skills needed for students pursuing STEM careers. The acquisition of these career readiness skills alongside of STEM literacy in the 21st century is vital to create a competitive workforce in the United States as well as globally (Bybee, 2010; US Dept of Labor, 2018; Wagner, 2008; Windschitl, 2009).

In the newly evolving science standards (e.g. Next Generation Science Standards), this shift towards the integration of career readiness (i.e. 21st century skills) can be seen. For example, in life science, students in a rote learning environment would be concerned with the definition of photosynthesis. However, through hands-on activities and engagement in an aquaponics classroom system, the students can see and understand firsthand how this phenomena occurs. Through representations such as these, students can begin to comprehend how changes in the environment impact phenomena, which goes towards systems thinking (NDE, 2017; NGSS Lead States, 2013; Windschitl, 2009). Knitting these 21st century career readiness skills together with STEM activities informs a framework that can be utilized with the “T” in STEM. Assessment frameworks for professional skills across STEM, especially those focusing on IT, are in their infancy (Kulturel-Konak, Konak, Esparragoza, & Kremer, 2013, pp. 1–4), even though these frameworks are highly needed.

1.3. Problem-based, hands-on learning in STEM, highlighting IT

In order to realize the 21st century career readiness skills with IT, STEM outreach should emphasize the development of hands-on, problem-based learning. These education plans, can create excitement for IT in an attempt to grow the future pool of high skill workers. STEM outreach should move past students performing rote learning and shift towards designing activities where real-world issues are addressed. STEM outreach should also concentrate on working with teachers to bring them alongside the students with these enriched activities. Many teachers do not have the rigorous undergraduate research training needed to combine the 21st century career readiness skills with the problem-based, experiential hands-on learning to create an enhanced learning environment (Kloser, Wilsey, Twohy, Immonen, & Navotas, 2018; Windschitl, 2009).

Problem-based learning (PBL) first evolved from Barrows and Tamblyn (1980) who found PBL created a useable, immediately applied form of knowledge students who became physician's needed instead of rote memorization of skills. Savery (2015), capitalized on Barrows original framework and strongly reiterated that PBL empowers students to solve their own problems, their self-based research meshing theory, and practice into one to solve a problem with a workable solution. This was not limited to the medical field but has wide applicability.

Integrating problem-based learning into the Technology in STEM should also incorporate a hands-on aspect giving students exposure to problem-based learning inside a hands-on, real-world emulated environment. Duran and Sendag (2012) found that by utilizing various hands-on, collaborative technological activities, critical thinking increased significantly in urban high school students. This is similar to recent findings by Duran and Sendag (2012) and Vennix, den Brok and Teconis (2018), who found that high school students' motivation to learn was significantly higher when presented with hands-on, problem-based STEM learning versus traditional lecture-based learning. Specific skills that develop from problem-based, hands-on learning activities are critical and analytical thinking regarding real-world problems, cooperative learning and communication skills, and the promotion and sense of self-efficacy. These aforementioned 21st century career readiness skills are precariously enmeshed within the skills needed to succeed in a technical STEM career (Baran & Maskan, 2010; Duch, Groh, & Allen, 2001; Hmelo-Silver, 2004; Schrum & Levin, 2016; Torp & Sage, 2002).

Without this problem-based, hands-on technical environment, some students may struggle in STEM-related courses, especially in regards to underrepresented students. Hands-on, problem-based learning has not only been shown to generate the development of key technical (the “T” in STEM) skills, but these activities have also been shown to engage underrepresented populations, like girls and young women, in science and technology activities (Little & León de la Barra, 2009; Nugent et al., 2010). In fact, hands-on, PBL may serve to engage and attract more females into the related professions (Diekman, Clark, Johnston, Brown, & Steinberg, 2011; Kiwana, Kumar, & Randerson, 2011; Lou et al., 2011). Indirectly, these same hands-on activities resonate well with minority groups (i.e. Latinos and Hispanics) allowing for a broader impact (Han, Capraro, & Capraro, 2014; Hayden, Ouyang, Scinski, Olszewski, & Bielefeldt, 2011). Recently, Marshall and Harron (2018) modeled a framework that meets both the needs of education standards while allowing for STEM, problem-based, hands-on activities in the classroom.

Without hands-on, PBL, students are unable to see the relationship between theory and practice, which creates frustration towards the acquisition of STEM concepts. Within the collaborative, hands-on environment of the STEM outreach initiatives, students may avoid this frustration and feel more engaged and interested in continuing to pursue STEM-related courses and even careers.

2. Method

This study used a mixed methods approach to determine whether there was a change in the perceptions of skills needed to pursue a career in computer science and information technology (IT) over a period of time.

Table 2
Participants and time periods for pre and posttest.

	N	Pre-Test	Post-Test	Interventions	Elements Targeted
6^{th} Grade	225	Week 1	Week 6	Presentation on different IT careers by IT industry personnel; interactive discussion of industry personnel with students on Scratch programming project	Knowledge of IT; Career Interest in IT
7^{th} Grade	331	Week 4	Week 16	Raspberry Pi module done in classroom with middle school teacher; Teacher emphasizes that module was designed by IT industry personnel	All
8^{th} Grade	89	Week 4	Week 16	Two separate hands-on lab activities done in conjunction with IT industry personnel: 1) Raspberry Pi & web server lab; 2) Wireless beacon lab	All

2.1. Participants

Participants (overall $n = 645$) included middle school students in grades 6th, 7th, and 8th grade located in two rural schools in the Midwest. Different groups of students in two middle schools were surveyed at different times intervals (Table 2) with the shortest being 6-weeks. The above students were chosen because the instructors were currently participating in a program called Nebraska Developing Youth Talent Initiative. The instructors ($n = 4$), who were the primary teachers of the participating students, were willing to work with IT industry partners to develop and implement a STEM curriculum. This curriculum was focused specifically within computer science and IT. The curriculum was created to allow students a direct exploration of hands-on activities that were directly tied to computer science and IT career choices.

2.2. Project collaboration

In this project, a web applications technology company located in a rural community chose to participate and collaborate with researchers at the local university to create this STEM outreach program. The small company provided two of their full-time employees to fully collaborate in developing the technical projects and curriculum hand-in-hand with university researchers. These employees also served as classroom mentors to provide professional practice expertise, give presentations and help with the STEM hands-on projects for these future young professionals. This company was not only passionate about the further integration of STEM into middle school curriculum, but also wrote and received a grant to fund new equipment for the middle schools as part of the STEM outreach.

2.3. Protocol

An online survey was distributed to all 6th grade students during the last two rotations of a 6-week Career Decisions course. The survey was also distributed to all second semester 7th and 8th grade students who were part of the Industrial Technology program. This survey was co-created by the research team through a iterative process in conjunction with specific members from the local web applications company. The survey was then piloted with a group of middle school students and teachers to ensure that wording was at an appropriate level. After this pilot, the research team and members of the local web applications company reconvened in a board discussion to make small changes to the wording of two questions. The distributed web-based survey was geared to test middle school students on three different constructs: 1) the perceptions of career readiness skills; 2) the perceptions of the skill set needed to pursue a career in IT; and 3) the perceived roadblocks that would prevent a student from pursuing an IT career (Appendix A & B). These elements were chosen based on statewide career readiness standards (NCE, 2011) alongside of the) framework. The primary instructors of the participating students were interviewed using a semi-structured, short answer format to gather further information about the integration of the program into the classroom. This interview was to promote understanding for future teachers, who were interested in integrating more STEM elements into their classrooms.

Before measuring reliability, a correlation matrix was examined to re-affirm the three constructs, which are mentioned above. In the correlation matrix, survey items 1 through 4 had a moderate positive inter item correlation with one another while survey items 5 through 6 also had a positive inter item correlation with one another. Reliability for the instrument was then measured on the first construct using Cronbach's alpha on both pre ($\alpha = 0.72$) and posttest ($\alpha = 0.68$). However, Cronbach's measurement can underestimate scales consisting of fewer than 10 items (Herman, 2015; McMillan & Schumacher, 2001). Since the first construct consisted of four items and the second consisted of only two items, a mean inter-item correlation test was performed to reaffirm the reliability of the first construct and to measure the second (Table 3). Ideally, average inter-item correlation should be between 0.20 and 0.40 suggesting that the items are measuring the same construct but contain enough unique variance between one another (DeVellis,

Table 3
Correlations between survey items.

	PreQ1	PreQ2	PreQ3	PreQ4	PreQ5	PreQ6
PreQ1						
PreQ2	0.353					
PreQ3	0.419	0.207				
PreQ4	0.456	0.348	0.479			
PreQ5	0.107	0.210	0.162	0.148		
PreQ6	0.041	0.102	0.096	0.101	0.372	
	PostQ1	**PostQ2**	**PostQ3**	**PostQ4**	**PostQ5**	**PostQ6**
PostQ1						
PostQ2	0.159					
PostQ3	0.173	0.148				
PostQ4	0.236	0.166	0.323			
PostQ5	0.081	0.123	0.093	0.079		
PostQ6	0.093	0.092	0.062	0.083	0.269	

2003). Based on these measurements, both constructs proved to be reliable scales as first construct measured pretest mean $r = 0.393$ and posttest mean $r = 0.200$; second construct measured pretest $r = .372$ and posttest $r = .269$.

2.4. Computer science and IT curriculum interventions

Between the pre and posttest surveys, different interventions for each group were performed (Table 2). For the 6th grade groups (8 different groups; $n = 225$), an industry-led presentation was incorporated into class time that specifically covered all identified career readiness skills needed for a wide array of computer science and IT careers. These industry-led speaking engagements described different IT projects, the technology being used, and the design process used to create the projects. One week before the presentation, the 6th grade students were led through a series of activities by the regular classroom instructor where they learned how to do simple programming through a free, web-based programming language and community called Scratch (https://scratch.mit.edu). After the presentation, a question and answer session followed and then the IT company personnel had students present their Scratch projects for positive, instructional feedback.

The 7th grade (4 different groups; $n = 331$) students were provided hands-on, project-based and entrepreneurial problem-solving experiences using such technology as a CNC (computer numerical control) router (i.e. computer-directed material cutting machine) and Raspberry Pi (i.e. small, low-cost computer) to produce actual products, controlled by software. Personnel from an IT company, mentioned above, worked closely with researchers from the university and middle school instructors to develop this hands-on activity. Upon completion of the projects, students were required to demonstrate and defend their market viability to local industry mentors, who formed an expert evaluation panel to rank student projects and give immediate feedback.

The 8th grade students (4 different groups), and the personnel from an IT company worked with the university and middle school instructors to develop two hands-on activities that worked directly with web and systems technology within the IT field. During this section of the project, students ($n = 89$) began to learn the basics of the software development life cycle and were introduced to applications such as *Android App Maker*. Guided by the C4C (Middle School Curriculum for Careers) Curriculum (NCE, 2011), students alongside of the IT industry mentors were introduced to WordPress® (i.e. an open-source widely used web content management system), in which they developed websites, and completed hands-on, problem-based activities using Raspberry Pis and other technology. The students also participated in a "Beacon Project," which entailed a school-based scavenger hunt that utilized GPS (global positioning system) technology.

2.5. Measures

The measures for career readiness skills were framed from state career readiness standards (NCE, 2011). The state standards list 11 career readiness criterions. Four of these standards were used in this study for measurement and included: 1) communicating effectively and appropriately; 2) making sense of problems and preserving in solving them; 3) uses critical thinking and 4) works productively in teams and demonstrates cultural competency. These standards are backed by the Kulturel-Konak et al. (2013) framework, which has an emphasis on increasing interest and knowledge within professional skills (career readiness skills) in STEM fields. Using this framework as a foundation, the survey consisted of six 5-point Likert-scaled questions with one open ended, short answer question. All survey items were statements, with which students could agree or disagree (1: strongly disagree – 5: strongly agree). An example of a survey question was: "In any job, it is important to be able to communicate effectively (both speaking and writing)."

2.6. Quantitative analysis

The six 5-point Likert-scale questions tested the first two of the aforementioned elements through six dependent variables: 1) the perceptions of career readiness skills broken down in four dependent variables: communication skills, teamwork, problem solving, and critical thinking); 2) the perceptions of the skill set needed to pursue a career in IT broken down into two dependent variables: IT career knowledge and IT career interest. These dependent variables were quantitatively analyzed through a repeated-measures one-way ANOVA against the factor of time ($p < 0.05$). For the first two elements, two main research questions were examined and the following null hypothesis is assumed:

H_0: population means at the two different time points are equal (i.e. $\mu_{pre} = \mu_{post}$).

2.7. Qualitative analysis

The third survey element (e.g. the perceived roadblocks that would prevent a student from pursuing an IT career) sought out the "why" from students through an open-ended, short answer question. The responses from this question were inductively analyzed and iteratively coded into themes (Corbin, Strauss, & Strauss, 2014; Ritchie & Spencer, 2002) both with pretest and posttest results. The students' responses could be across multiple themes, and so some responses reflected multiple-themed coding. The procedure used (detailed in Table 4) also reflects a pre and posttest comparison of themes to determine whether perceptions shifted after intervention. The open-ended question was not mandatory and total responses per grade are noted later in the results section.

The four instructors involved in this project were also interviewed using a semi-structured format. These questions revolved around how the project helped with STEM-related lesson planning and overall satisfaction with the STEM outreach activities. Because the nature of these interviews goes more towards the discussion of STEM outreach, the teacher responses will be incorporated later in

Table 4
Qualitative analysis procedure of open-ended question.

Step	Description
Coding Procedure	Coding procedure was established between first and second authors. Open-ended question on survey *the biggest challenge as you picture yourself in an IT career* was the overarching question used to approach the open responses
Pretest Phase Coding	First and third author iteratively and independently coded the short answer question results using the short answer question as a guide.
Posttest Phase Coding	Again, first and third author iteratively and independently coded the short answer question results using the short answer question as a guide.
Reviewing Codes	Third author submitted the codes to the first author. The first author then reviewed the codes, marking dissimilar codes. Dissimilar codes were resolved together.
Pre-post comparison	Pre- and post-test codes were reviewed by the first author and compared. Differences in themes and number of theme occurrence were noted.
Results	Results are displayed by theme and then by pre- and post-test.

the Discussion section.

3. Results

Research question 1: Was there a difference in perceptions of required career soft skills by time?

A multi-variate ANOVA was used to determine whether there was a change in the perceptions of the soft skills set needed to pursue any career over a period of time. This analysis was used in place of multiple one-way ANOVAs to limit Type I errors and reveal any differences that cannot be discovered by multiple one-way ANOVAs. Each grade within the middle school conveyed an increase in mean score for each of the soft skill categories (Table 5). Overall in the middle school, the mean score significantly increased in each category. Although the 6th graders did rate their perceptions of the importance of soft skills higher on the posttest than pretest in all categories, only the teamwork and critical thinking categories were significantly higher.

Each grade within the middle school reported an increase in mean score posttest in their knowledge of IT careers (Table 6), with 6th grade and 7th grade reporting a significant increase. Overall in the middle school, a significant increase in mean scores occurred in overall IT career knowledge. However, in terms of IT career interest, 6th and 7th grade reported a slight decrease while 8th grade saw a slight increase. However, these changes in pretest and posttest scores were not significant. Overall, the scores for IT career interest decreased slightly.

The main question of *what is your biggest challenge as you picture yourself in an IT (information technology) career* was used to guide the coding both pre and posttest. Pretest responses suggest that students, particularly those in the 6th grade, did not have true knowledge of what the acronym IT represented. Students responded with answers like, *"construction"; "plumbing because the pipes would be hard to screw and stuff"; "using power tools";* and *"building houses"*, which led the researchers to believe that students thought IT was short for ITEC. ITEC (Industrial Technology) was a series of applied programs in these middle schools that led students through a myriad of projects emphasizing construction, welding, basic electronics and mechanics. Through the iterative process (Table 4), pretest results were coded and fell into five main groups (Table 7).

In the pretest, many students expressed the belief that their biggest challenge lay within their own efficacy – not having the skills and not being able to learn the skills required for an IT career. Students with this belief responded with things like:

"MATH it is HORRIBLE." "SCIENCE!" "Working with math problems."

"IT is a hard subject." "I'm not good at computers."

"That it will be hard and confusing." "That I won't understand." "I couldn't do it."

"I have trouble understand engineering."

"I won't know what I'm doing. Not knowing what or how to solve the complicated problems."

Students also did not know if they would have the soft skills needed in an IT career:

"*My biggest challenge in an IT career would be solving problems every single day of my whole life that are very difficult and challenging."*

"Conflict with different people would be challenging."

"To communicate well with others."

"Solving problems every single day of my whole life that are very difficult and challenging."

Students were also confused about what IT was and what type of job they would be able to do with such a career:

"I honestly have never heard of IT. I might not have the knowledge."

"I don't know what IT is."

Table 5
Overall changes in career readiness skills for any career.

Research question 2: Was there a difference in perceptions of IT careers by time?.

Communication						
	N	*M*	*SD*	*F*	*P*	H^2
6th Grade Pretest	225	4.55	.646	(1224) = 1.021	.313	.005
6th Grade Posttest	225	4.64	.655			
7th Grade Pretest	331	4.47	.688	(1330) = 9.031	.003**	.012
7th Grade Posttest	331	4.62	.587			
8th Grade Pretest	89	4.57	.601	(1,88) = 3.887	.052*	.042
8th Grade Posttest	89	4.75	.589			
Overall Pretest	645	4.51	.660	(1644) = 13.266	.000*	.020
Overall Posttest	645	4.64	.620			
Teamwork						
	N	***M***	***SD***	***F***	***p***	η^2
6th Grade Pretest	225	4.46	.694	(1224) = 5.113	.025*	.022
6th Grade Posttest	225	4.64	.591			
7th Grade Pretest	331	4.42	.752	(1330) = 7.601	.070	.000
7th Grade Posttest	331	4.44	.962			
8th Grade Pretest	89	4.33	1.022	(1,88) = 7.111	.009**	.075
8th Grade Posttest	89	4.57	.999			
Overall Pretest	645	4.42	.766	(1644) = 4.914	.023*	.008
Overall Posttest	645	4.59	.697			
Problem solving						
	N	***M***	***SD***	***F***	***p***	η^2
6th Grade Pretest	225	4.56	.766	(1224) = 2.706	.101	.012
6th Grade Posttest	225	4.67	.550			
7th Grade Pretest	331	4.49	.748	(1330) = 21.692	.000**	.062
7th Grade Posttest	331	4.73	.478			
8th Grade Pretest	89	4.52	.854	(1,88) = 4.408	.039*	.048
8th Grade Posttest	89	4.76	.658			
Overall Pretest	645	4.52	.754	(1644) = 26.191	.000**	.039
Overall Posttest	645	4.69	.545			
Critical thinking						
	N	***M***	***SD***	***F***	***p***	η^2
6th Grade Pretest	225	4.38	.759	(1224) = 10.058	.002**	.043
6th Grade Posttest	225	4.50	.708			
7th Grade Pretest	331	4.35	.837	(1331) = 13.304	.000**	.039
7th Grade Posttest	331	4.56	.631			
8th Grade Pretest	89	4.37	.958	(1,88) = 6.095	.015*	.065
8th Grade Posttest	89	4.69	.632			
Overall Pretest	645	4.33	.864	(1644) = 21.290	.000**	.032
Overall Posttest	645	4.52	.653			

Notes: $^*p < 0.05$; $^{**}p < 0.01$; values recorded as 0.000 equate to $p < 0.0005$.

"I don't have a visual in my head about what an IT career is."

"Understand what IT is in a specific job."

During the posttest coding, student responses shifted away from ITEC and were redirected into more knowledgeable types of responses, which were categorized into four groups (Table 6). Students again expressed concerns about their level of knowledge and their own ability to obtain the necessary skills needed in an IT career. Students also reiterated thoughts about not being able to handle problems, communicate properly or work in teams. Students did shift away from confusion about what IT was and into a more future-oriented type of thinking wondering if they would be able to attend college to get a degree and start their IT careers:

"Go to college and pay for college."

"Pay for everything while in college." "Money to go to college."

"Getting into a good college, earning enough money, and getting good enough grades."

Some students still expressed no interest in IT because they were focused on other career pathways.

Table 6
Overall changes in IT career knowledge & interest.

Research question 3: What perceptions would prevent a middle school student from pursuing an IT career?.

IT Career knowledge						
	N	*M*	*SD*	*F*	*P*	H^2
6th Grade Pretest	225	3.18	.939	(1224) = 8.482	.004**	.036
6th Grade Posttest	225	3.46	.845			
7th Grade Pretest	331	3.19	.986	(1330) = 6.882	.009**	.020
7th Grade Posttest	331	3.38	.947			
8th Grade Pretest	89	3.64	.920	(1,88) = 0.659	.419	.007
8th Grade Posttest	89	3.76	.905			
Overall Pretest	645	3.27	.968	(1644) = 16.266	.000**	.024
Overall Posttest	645	3.42	.866			
IT Career interest						
	N	***M***	***SD***	***F***	***p***	η^2
6th Grade Pretest	225	2.94	1.055	(1224) = 0.261	.610	.001
6th Grade Posttest	225	2.89	1.115			
7th Grade Pretest	331	2.66	1.086	(1330) = 0.014	.901	.000
7th Grade Posttest	331	2.65	.906			
8th Grade Pretest	89	3.24	1.058	(1,88) = 0.507	.507	.006
8th Grade Posttest	89	3.36	0.869			
Overall Pretest	645	2.84	1.08	(1644) = 0.114	.915	.000
Overall Posttest	645	2.81	1.04			

Notes: $^*p < 0.05$; $^{**}p < 0.01$; values recorded as 0.000 equate to $p < 0.0005$.

Table 7
Qualitative themes – pretest and posttest.

Pretest themes	Posttest themes
ITEC – Students thought that IT stood for ITEC	***Efficacy*** – Students were worried that they did not have the appropriate math skills or technical skills to succeed in IT
Efficacy – Students were worried that they did not have the appropriate math skills or technical skills to succeed in IT	***Soft skills*** – Students do not know if they would be able to work in a team or solve the problems that would occur
Career pathways (don't know) – Students were confused about which job they would be able to obtain and what an IT career was	***Anxiety about college*** – Students expressed desire to stay in school, but anxiety about getting to college
Soft skills – Students do not know if they would be able to work in a team or solve the problems that would occur	***No interest*** – Students reported no interest in IT
No interest – Students reported no interest in IT	

4. Discussion

STEM outreach initiatives are invaluable not only to the students inside the classroom but also to the teachers for continued instruction. STEM initiatives should continue to improve on the 21st century career readiness skills by continuing to intertwine IT (as the Technology in STEM) through problem-based, hands-on learning activities that can be incorporated either inside or outside of the classroom.

4.1. Continued real-world industry development in the classroom

According to the quantitative responses collected, rural students, on posttest, understood the importance of career readiness skills in the IT industry, which adds to current STEM research done in urban areas (Bass et al., 2016; Mattern et al., 2016). In fact, the hands-on, problem-based activities incorporated into the 7th and 8th grade class time significantly impacted the 21st century career readiness survey scores. Expanding the STEM outreach partnership model developed in this project between industry companies, professionals and middle schools that will further enrich the learning available within the classroom and increase awareness of career readiness skills. This expansion of the STEM outreach partnership would also distribute any costs and resources needed across multiple stakeholders to facilitate sustainability. Including school administrators throughout such outreach projects would also help integrate these type of initiatives more fully in the long-term. Involving more stakeholders would also give the teachers and students a way to expand the types of technical real-world projects that could be incorporated into the classroom. Further, continued interactions between industry and students may help nurture confidence in their technical and non-technical abilities, as a lack of efficacy seemed to be a prevalent theme in students' open-ended responses. Students in rural communities, similar to this project, might also deal with situations that are unique to rural clients, and so a variety of stakeholders could provide dynamic opportunities that will best prepare rural students for higher education.

During the semi-structured interviews with the teachers, they described the unique dynamics of group learning and team activities in a positive light, which the STEM outreach activities in this project enforced and measured in the teamwork variable. One teacher mentioned that the project really “broadened his emphasis,” noting that he learned of different jobs and sought to impart to the students more “flexible” skills as the IT jobs that will be available when they enter the workplace aren't “even invented yet”. This only re-enforces the idea that industry needs to be continually involved in the STEM outreach activities to help plan and improve upon the engagement of young minds within the STEM fields, especially that of the IT field. Even though there was a learning curve and challenges, all teachers highly rated the implementation of the STEM outreach activities and wanted more interaction with future projects. Interaction with the students during the projects, reiterated these same thoughts.

4.2. Continue to expose students to real-world, hands-on, problem-based IT learning

Overall, student scores within IT career knowledge significantly increased. This suggests students started to understand the differences between IT careers and different technical skills needed to accomplish the job. Students were taught about the different IT careers and skills alongside of the 21st century career readiness skills. Since both career readiness and IT career knowledge significantly increased, the method used here worked to increase not only technical knowledge but also increase student career readiness skills. Teaching these activities as hands-on, problem-based learning modules is part of the puzzle that allowed the students to make increases in both areas.

During the semi-structured interviews with the four middle school teachers, one teacher described the implemented curriculum as becoming more “intentional” in its focus on IT, while one teacher found that learning within his classroom was more “rich” in its IT content. This intentional focus within a high technology system allowed students to directly explore in a hands-on, problem-based environment, which was highly engaging. Several teachers also noted that the equipment provided (e.g. CNC routers, Raspberry Pis and wireless beacons) required the teachers to think “outside of the box” in how they could utilize these learning tools for students. Another teacher found that the project forced him to view his approach to his learning modules (i.e. lessons) differently. Kloser et al. (2018) and Windschitl (2009) found in other STEM areas that teachers would need to experience the new teaching activities alongside of students, particularly if the activities were hands-on, in order to successfully implement the new curricula.

From the teacher interviews as well as through the observation of the wireless beacon hands-on, problem-based learning activities, students were most engaged by hands-on and interactive activities. Often, these activities lend themselves to the development of teamwork, communication, problem-solving and critical thinking skills, all emphasized in the STEM outreach modules. These basic activities build confidence and should be considered in order to address students' fear of failure and promote confidence in their technical abilities. Even though overall the student's scores did not increase in IT career interest, the 8th grade students did experience an increase in IT career interest. The 8th grade students were more exposed to hands-on, problem-based activities, than any other group. Thus, an inference could be made that the more hands-on, problem-based learning in IT-based activities, the more interest and engagement will increase. Similar to research done in other STEM areas with high schoolers (Duran & Sendag, 2012; Vennix, den Brok, & Taconis, 2018), teaching the T in STEM by incorporating hands-on, problem-based learning activities seemed to increase interest in middle schoolers.

The difference in pretest and posttest short answer questions made clear that the students level of knowledge and interest about IT shifted. Some of the students mistakenly thought (pretest) that this short answer question was asking them about challenges within an ITEC career. During the posttest, this confusion went away allowing the students to focus on other issues, such as getting through school and then on to college. The students now better understood the pathway to succeed in a future IT career.

4.3. Limitations & future

Although this project was successful in building towards short term goals, the long term sustainability presents a potential problem. Shortly after this project ended, one of the middle school teachers resigned and the new teacher was not as receptive to the STEM outreach initiative. Currently, a couple of industry companies have learning labs for the STEM outreach program, but no transportation has been made available for teachers to attend the activities. In reflection, although the school administrators were involved in the process, outreach projects may need to pull administrators more fully into the activities. In this manner, the administrators can see, firsthand, the impact the activities are having on the students. To continue to sustain the program activities, one company, in coordination with the middle school and the researchers, designed activity worksheets for the students and shared these documents in digital format with the teachers. Furthermore, this identified company had mentors that designed and shared student and instructor manuals so that the teachers could implement the activities without the anxiety that sometimes accompanies such an endeavor. This company also built the backend system in a sustainable, low-maintenance manner. This system can continue to run without funding for a minimum of three continuous years. At this point in time, the program can be either continued or revamped to incorporate the latest needs from industry and needs from the educational standpoint. Further work should also center around creating an IT-STEM based curriculum that included activities and learning labs across all middle school grades, that institutions or organizations could integrate and implement. In this study, the effect of hands-on, problem-based learning could be seen in the 8th grade group, which reflects that more hands-on, problem-based learning activities should be incorporated in all middle school grades. Not only could these be standalone programs but they could be combined into summer camps or after school programs.

Rural students can be considered at a disadvantage because STEM opportunities present in urban areas are often lacking in rural areas. Projects like ours provide immediate exposure that some students may not have the opportunity to experience. This also brings to light that students in rural areas, have very similar reactions to urban-based students during hands-on, problem-based learning. STEM education, specifically IT, is intertwined in all aspects of society. If this type of exposure results in the recruitment of future professionals, it contributes to the continual advancement to various professional fields that extend beyond IT.

5. Conclusion

In the meantime, the excitement created from the current STEM outreach program has not dwindled. Although transportation was an issue, the middle school teachers, encouraged by the students' excitement, are planning on participating in several training sessions at local companies to learn more hands-on, problem-based activities. This engagement and commitment shown from the middle school teachers will continue to drive this initiative far into the foreseeable future. This could create the environment needed to drive students towards an IT career increasing the pipeline from middle school students up through their career.

As a whole, the STEM outreach initiative appeared to have a positive impact on middle school students' awareness of IT and is fostering curricular and instructional reforms that may result in increased numbers of students taking elective coursework in IT, entering IT programs of study at the secondary level, and potentially pursuing careers in the IT field. It is also very encouraging to note that the teachers generally viewed the project as a “pilot project” and seemed genuinely enthusiastic and invested for continuing the program and making programmatic changes to further the project's impact. Continued interactions and involvement by industry and potentially other industry partners are necessary to sustain the industry-school (teachers and students) interactions, which appeared to have a positive impact on student awareness and curricular improvements.

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Appendix A. Supplementary data

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